MANAGEMENT OF DIETARY PHOSPHORUS IN DAIRY PRODUCTION SYSTEMS

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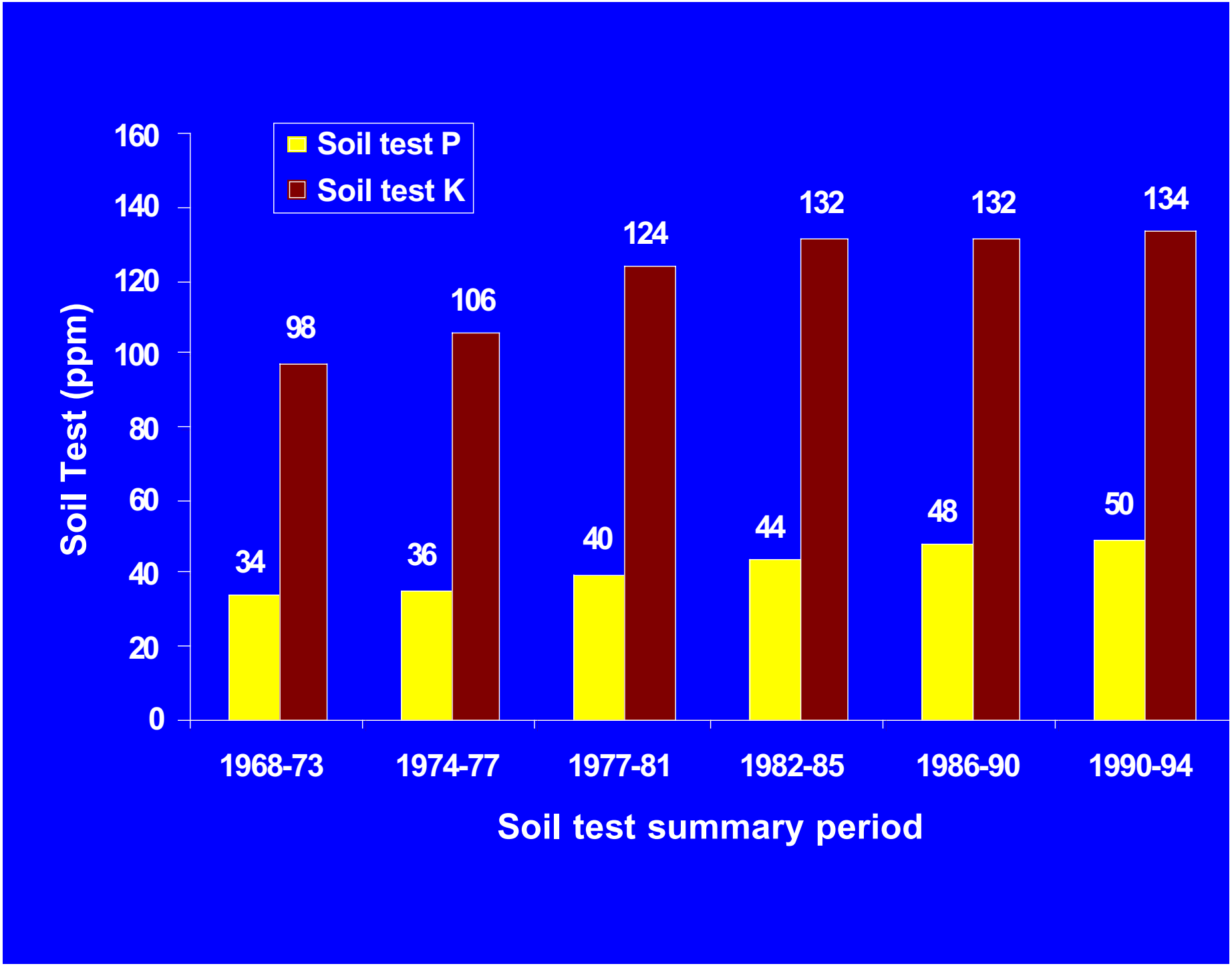
LET S TALK ABOUT PHOSPHORUS

P solubilized in surface water running off fields high in P content and P present in eroded soil particles

are the major sources of P entering our lakes and streams, causing them to turn green with algae a other plant and microbial growth.


Soil test P
Soil test K
Soil Test (ppm)
160
140
120
100
80
60
40
20
0
34
98
36
106
40
124
44
132
48
132
50
134
1968-73
1974-77
1977-81
1982-85
1986-90
1990-94
Soil test summary period

WE OVERFEED PHOSPHORUS TO OUR DAIRY COWS!!

CAN WE REDUCE IT?

THE ANSWER IS YES, AND

- We can save money (~$100 million per year).
- We can reduce the phosphorus threat to our environment.

HOW HAVE WE COME TO THIS POINT OF OVERFEEDING P?

1. Notion that increasing P improves reproductive performance
2. Absence of trials showing the absolute minimum of P required to support moderate to high levels of milk production.
3. Aggressive marketing of P supplements

The literature on P is quite clear and consistent.

It is the interpretations of the literature that are confusin

Phosphorus requirements for dairy cattle (from Tamminga, 1992)

Maintenance (g/kg BW)	Milk (g/kg of FCM)	% Availability	Country
.0286	1.98	50	US
.042	1.50	60	Netherlands
.0207	1.56	58	Great Britain
.062	1.25	70	France
.040	1.66	60	Germany

PHOSPHORUS FEEDING RECOMMENDATIONS

1320 lb cow 3.75% milk fat	Estimated DM intake	NRC Recommendations Old and New		German Recommenda	
Lbs milk/day	Lbs/day	P, g/day	Dietary P, %	P, g/day	Dietary
22	28.7	36.0	0.27	33.0	0.2
44	37.3	55.5	0.33	52.8	0.3
55	44.7	62.3	0.32		
66	44.8	74.5	0.37	72.0	0.3
77	51.9	79.6	0.35		
88	51.5	93.0	0.40	90.7	0.3
99	59.2	96.9	0.36		
110	60.1	112.5	0.41	110.6	0.4
120	66.0	113.1	0.38		

New NRC cow weighs 1496 lbs. Dietary P availability put at 71%

Milk Production Response to Dietary Phosphorus Level

Study	Dietary P (% of Diet DM)		Milk Production (lbs/day)	
	Low P	High P	Low P	High P
Kincaid et al, 1981 (20 cows/trt) (10 months)	.30	.54	61.6	66.0
Brintrup et al, 1993 (26 cows/trt) (two complete lactations)	.33	.39	55.9	53.9
Satter & Dhiman, 1997 (23 cows/trt) (12 wk mid lactation)	.39	.65	52.6	53.7
Wu et al, 1997[1] (24 cows/trt) (complete lactation)	.35	.45	65.3	63.6
Wu et al, 1998[1] (26 cows/trt) (first 27 wks of lactation)	.37	.48	86.5	84.7

[1]Unpublished studies, U.S. Dairy Forage Research Center, USDA-ARS.

ilk Production Response To Dietary Phosphorus Level (Continue

Study	Dietary P (% of Diet DM)			Milk Production (lbs/day)		
	Very Low P	Low P	High P	Very Low P	Low P	High P
Wu et al, 1999[1] (8-9 cows/trt) (complete lactation)	.32	.41	.51	77.1	80.2	79.5
Valk and Sebek (6-8 cows/trt) (wk 17-37)	.23	.27	.33	51.2	53.0	53.8
Valk and Sebek (6-8 cows/trt) (wk 2-31)	.24	.27	.34	Deficient	81.9	80.7
Average	–	.34	.46	–	67.1	67.0

[1]Unpublished studies, U.S. Dairy Forage Research Center, USDA-ARS.

Measures of strength of the 12th rib bon

tem	.31% P	.39% P	.47% P
Shear stress, N/mm^2	26.5	28.1	27.5
Fracture energy[1], N-m	66.6	60.5	65.0
Bone specific gravity	1.50	1.57	1.55

[1]Area under the force (N) and deformation (m) curve, an expression of the am
energy the bone absorbs before fracture.

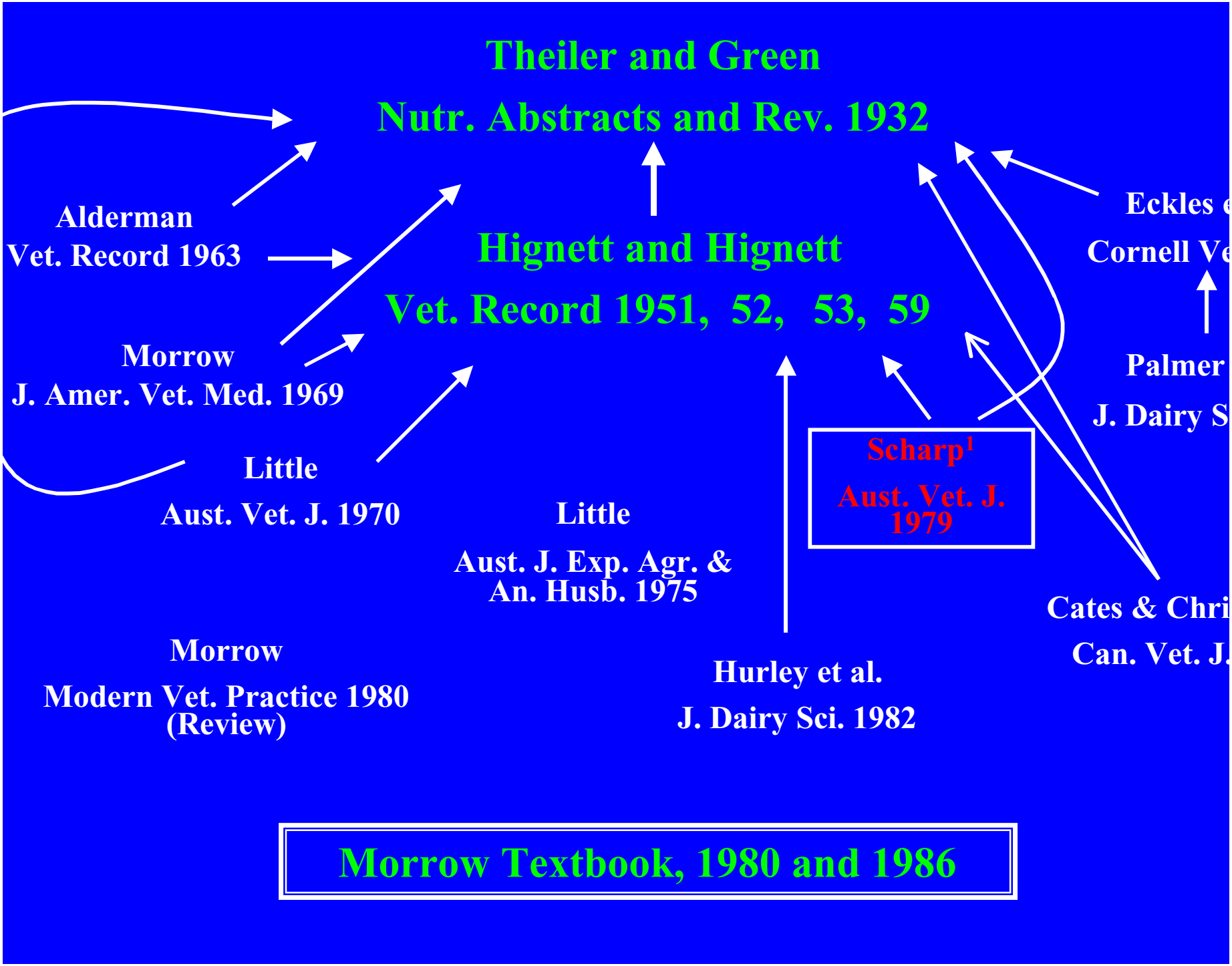
[a]Linear and quadratic ($P < .14$) effects.

Reproductive performance of heifers and lactating cows fed a low phosphorus or high phosphorus diet (Summary of 13 trials)

	Dietary P (% of DM)	Number of animals[1]	Days to first estrus	Days open	Services per conception	Days to first AI	Pregnanc rate (%
Cows (Lo)	.32 - .40	393	46.8	103.5	2.2	71.7	92
(Hi)	.39 - .61	392	51.6	102.1	2.0	74.3	85
Heifers (Lo)	.14 - .22	116			1.5		98
(Hi)	.32 - .36	123			1.8		94

[1]Not all of the measurements listed in this table were made in each and every trial. Thus each measurement is based on most, but not all, of the animals in column two.

GENESIS OF THE P MYTH


Theiler and Green
Nutr. Abstracts and Rev. 1932
Alderman
Vet. Record 1963
Hignett and Hignett
Vet. Record 1951, 52, 53, 59
Eckles
Cornell Ve
Morrow
J. Amer. Vet. Med. 1969
Palmer
J. Dairy S
Scharp[1]
Aust. Vet. J.
1979
Little
Aust. Vet. J. 1970
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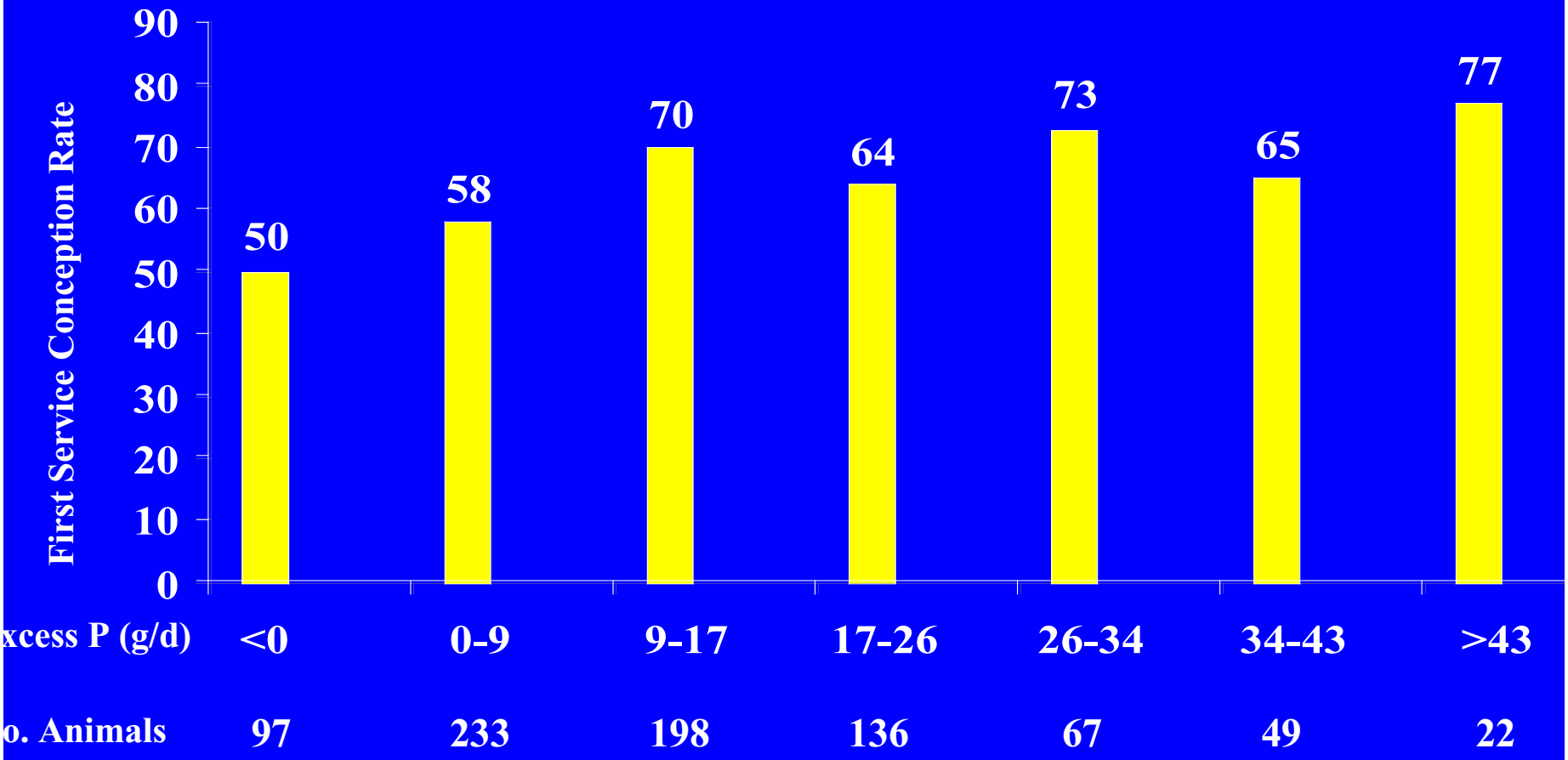
Aust. J. Exp. Agr. &
An. Husb. 1975
Cates & Chri
Can. Vet. J.
Morrow
Modern Vet. Practice 1980
(Review)
Hurley et al.
J. Dairy Sci. 1982
Morrow Textbook, 1980 and 1986

Relationship between P intake at time of first service and conception rate. (Hignett and Hignett. Vet. Rec., 1951.)

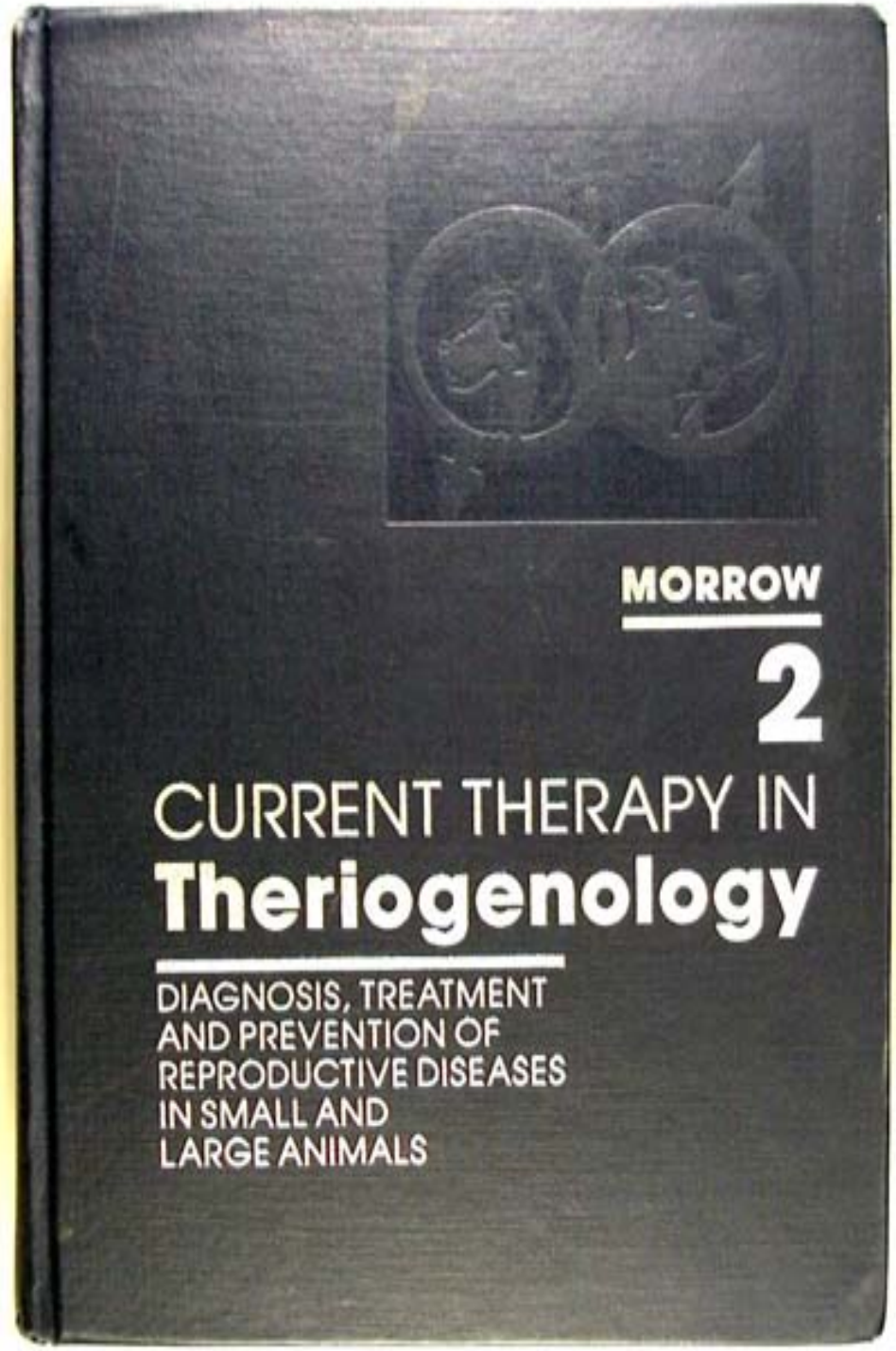


British Feeding Recommendation At The Time:

- ¥ 2.24 g P/kg milk
- ¥ 9.9 g P/day for maintenance

Assume 15 kg milk/day:

- ¥ British Standard = 43.5 g P
- ¥ 2001 NRC = 49 g P


MORROW
2
CURRENT THERAPY IN
Theriogenology
DIAGNOSIS, TREATMENT
AND PREVENTION OF
REPRODUCTIVE DISEASES
IN SMALL AND
LARGE ANIMALS

Phosphorus is the mineral most frequently associated with reproductive abnormalities in cattle. Clinical signs of a deficiency may include a delayed onset of puberty and postpartum estrus. Milder deficiencies have been reported to be associated with repeat breeding. Some clinicians have suggested that an increased incidence of cystic follicles may also be associated with a phosphorus deficiency, although documented reports are not available.

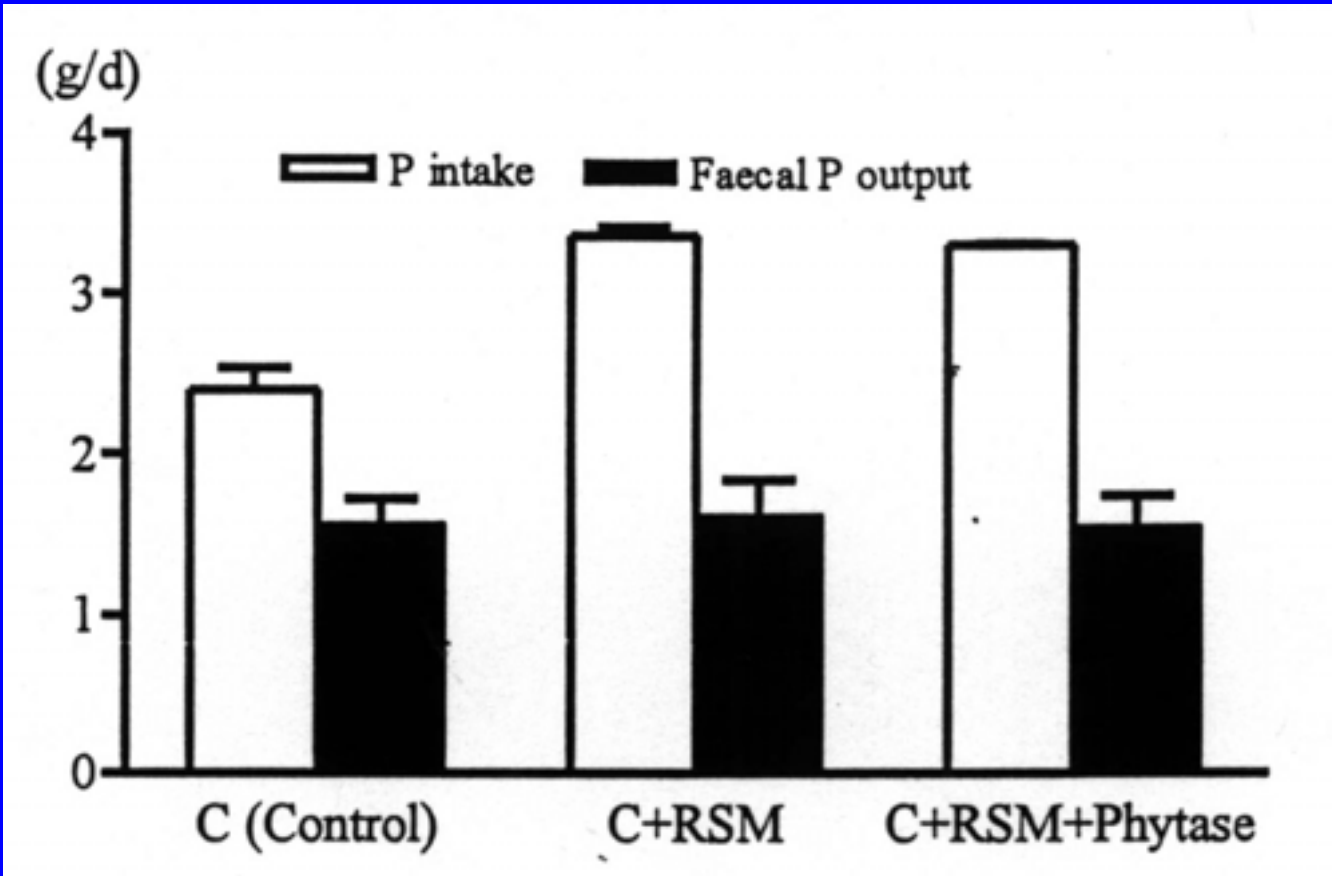
Pg. 318, Morrow.

PHOSPHORUS AVAILABILITY IN FEEDSTUFFS

MEASUREMENT OF PHOSPHORUS AVAILABILITY

STUDY	ANIMAL	AVAILABILITY
Koddebush & Pfeffer, 1988	Goat	~90%
Martz et al, 1990	Lactating Cows	64 to 75%
Weiss et al, 1986	Lactating Cows	60 to 65%
Lofgreen & Kleiber, 1953 and 1954	Sheep	81 to 96%
Kleiber, 1951	Lactating Cows	50 to 64%
ARC, 1981	Suckling calf	94%
	Calf, 19 months	78%
	Mature	58%

Effect of Supplementing P from Rapeseed Meal (RSM) on Intake and Faecal Output of P in Dairy Goats (means and SD)[1].



[1]Rodehutscord and Pfeffer, 2000.

Dietary P required = Absorbed P required / True digestibi

<u>True digestibility of P for different sources:</u>

Monosodium phosphate	**=**	**90%**
Dicalcium phosphate	**=**	**75%**
Concentrates	**=**	**70%**
Forages	**=**	**64%**

SOME PROTEIN SUPPLEMENTS BRING EXCESS P TO THE DIET

Protein and phosphorus content of some common feeds (NRC, 2001)

Feed	Protein % of DM	Nitrogen % of DM	Phosphorus % of DM	R
Bloodmeal	95.5	15.3	0.30	5
Soybean meal (48%CP)	49.9	8.0	0.70	1
Brewer s grains	29.2	4.7	0.67	
Cottonseed	23.5	3.8	0.60	
Corn distillers grains	29.7	4.8	0.83	
Corn gluten feed	23.8	3.8	1.00	
Wheat midds	18.5	3.0	1.02	
Wheat bran	17.3	2.8	1.18	
Meat and bone meal	54.2	8.7	4.73	

REDUCING DIETARY P CAN HAVE A VERY SIGNIFICANT IMPACT ON LAND REQUIRED TO UTILIZE MANURE P

Amount of land required to utilize manure P from cow produ
9,090 kg milk/305 d.

Dietary P Concentration	Estimated Supplemental P	Manure P	Land area needed to recycle manure P	Chan land
(%)	(kg/lactation)	(kg/lactation)	Acres	(%
0.35	0	15.8	1.3	Ba
0.40	3.4	19.2	1.6	2
0.48	8.9	24.7	2	5
0.55	13.7	29.5	2.4	8

Crop yields are typical for the midwest US, and crops remov
12.1 kg P per year.

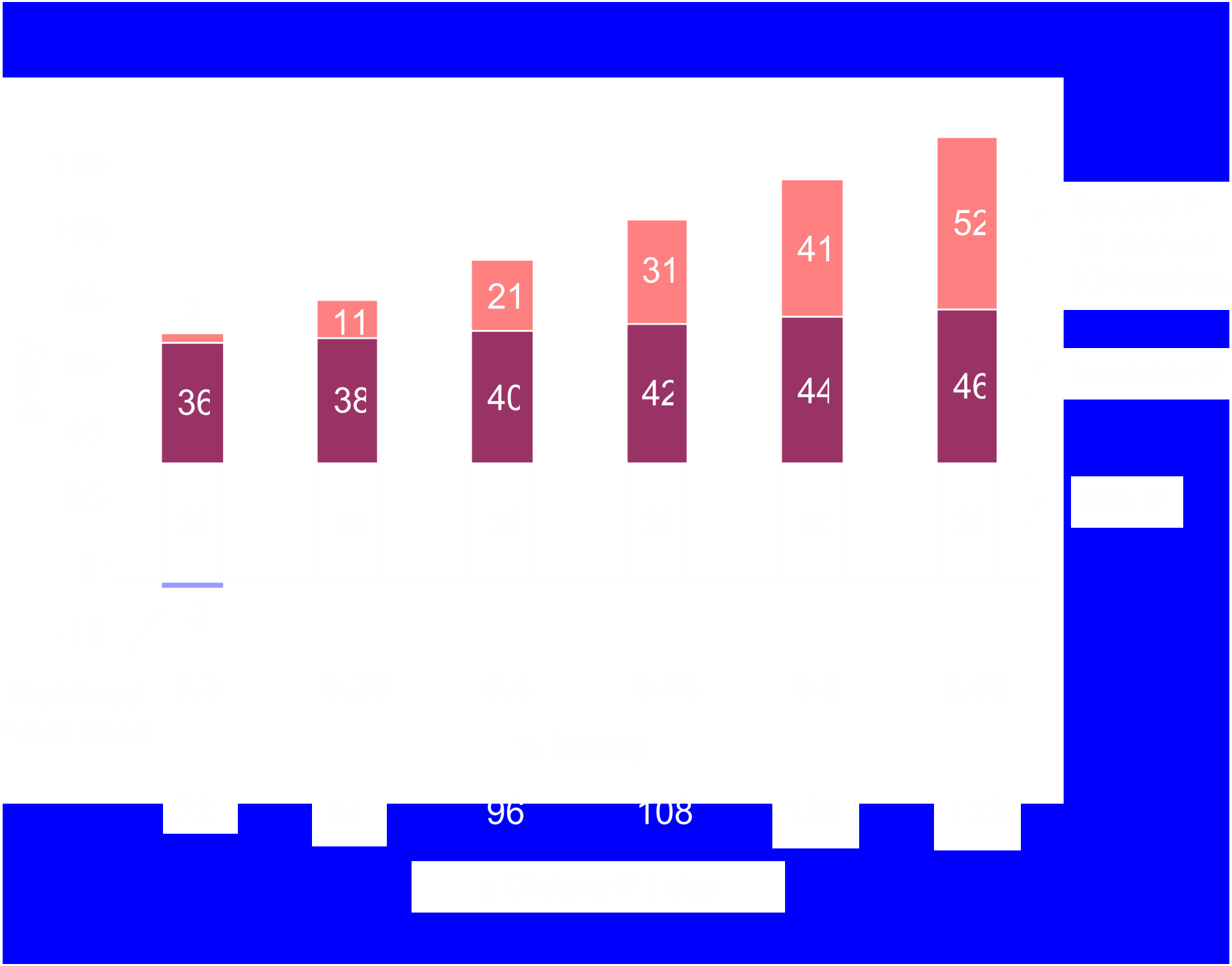
If All Grain Is Purchased and Forage Raised at Home

IMPORT		EXPORT	
2000 lb soybean meal	12.2	20,000 lb milk/yr	= 1
Dicalcium phosphate	3	Cull cows and calves	=
(To .38% P in diet)			
6000 lbs corn grain	16.2	Surplus feed	=
Forage	0	Manure	=
Fertilizer	0	Runoff	=
Total	31.4		2

REDUCING DIETARY P REDUCES OVERALL SOLUBILITY OF MANURE P

Manure from cows fed 0.48% P lost **10 times** as much P to runoff from agronomic plots as manure from cows fed 0.32% P.

When manure was applied to give equal P application rates, runoff was **4 times** greater with the high P manure.


36
38
40
42
44
46
3
11
21
31
41
52
96
108

IT IS OFTEN STATED THAT THE N:P RATIO IN MANURE IS ABOUT HALF WHAT IT SHOULD BE FOR OPTIMAL PLANT GROWTH

Range For Optimal Plant Growth **6-8 : 1**

N:P Ratio In Livestock Manure Before Field Applicatio
(Moreira and Satter, Unpublished)

Dairy (Slurry)	5.6	Broiler
Dairy (Daily Haul)	5.7	Swine (Finish)
Dairy (Bedded Pack)	4.8	Layer

ESTIMATED NITROGEN:PHOSPHORUS RATIOS IN MANURE AS INFLUENCED BY DIET AND MANURE HANDLING

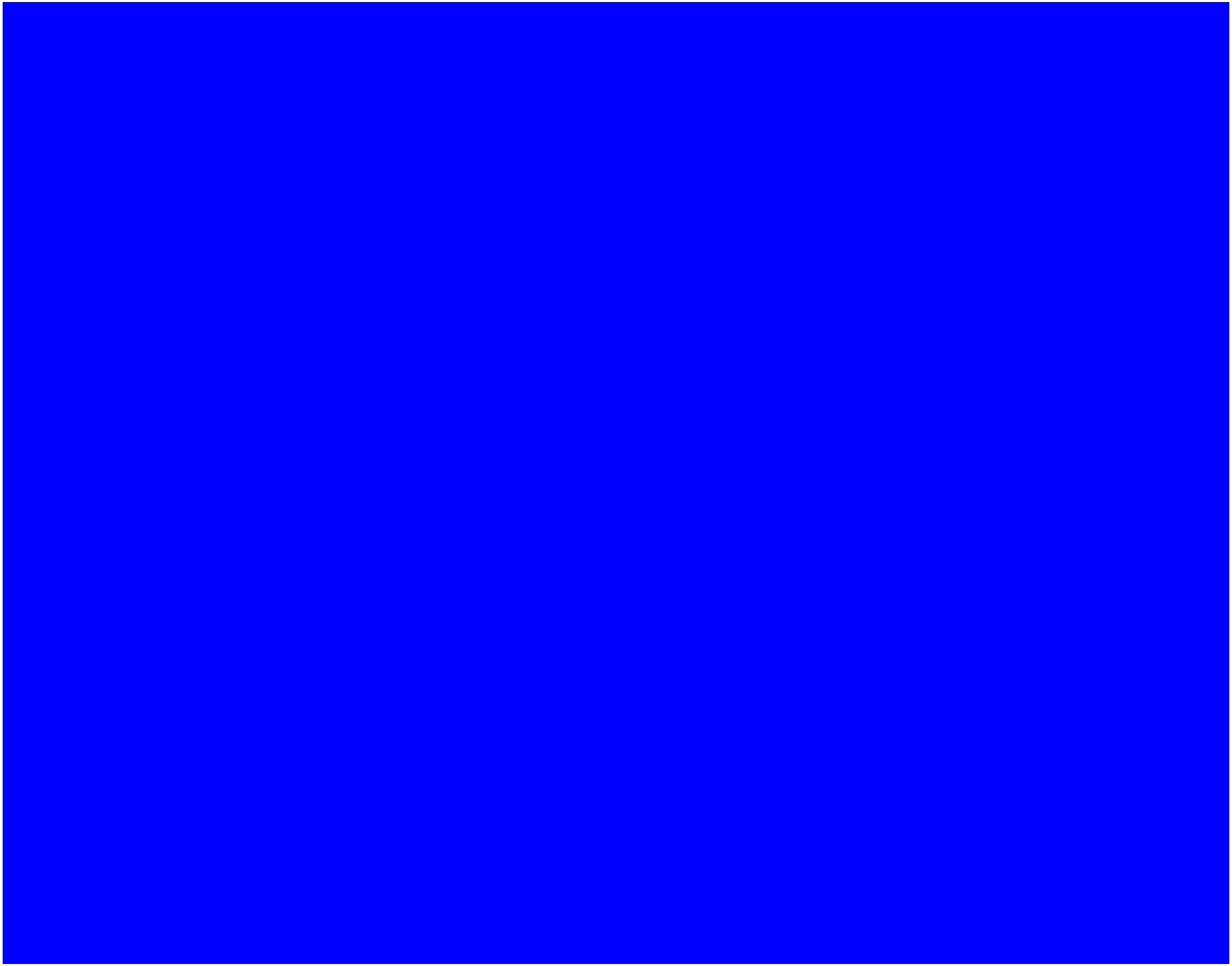
Diet		N:P Ratio			
Crude Protein	Phosphorus	At time of Excretion	Manure Coming Out of Storage	Manure Nutrients Incorporated in Soil With Surface Application	Manure Nu Incorpora Soil With R N Loss
17.5	0.45	6.8	5.6	4.4	5.3
17.2	0.38	8.7	7.1	5.5	6.7
16.0	0.38	7.8	6.6	5.4	6.3

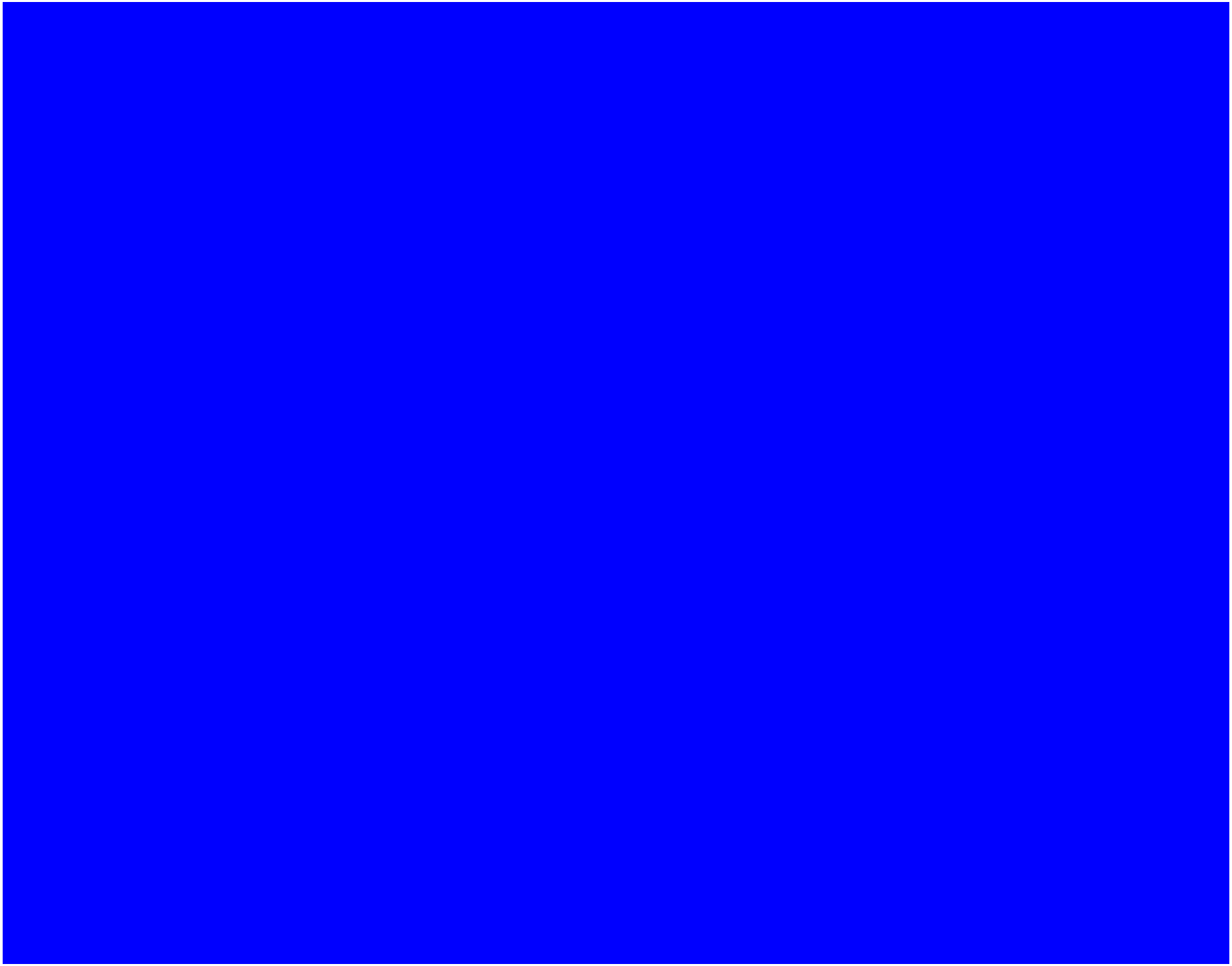
EPA Expected to Announce Changes to Rules Regulating Concentrated Animal Feeding Operati

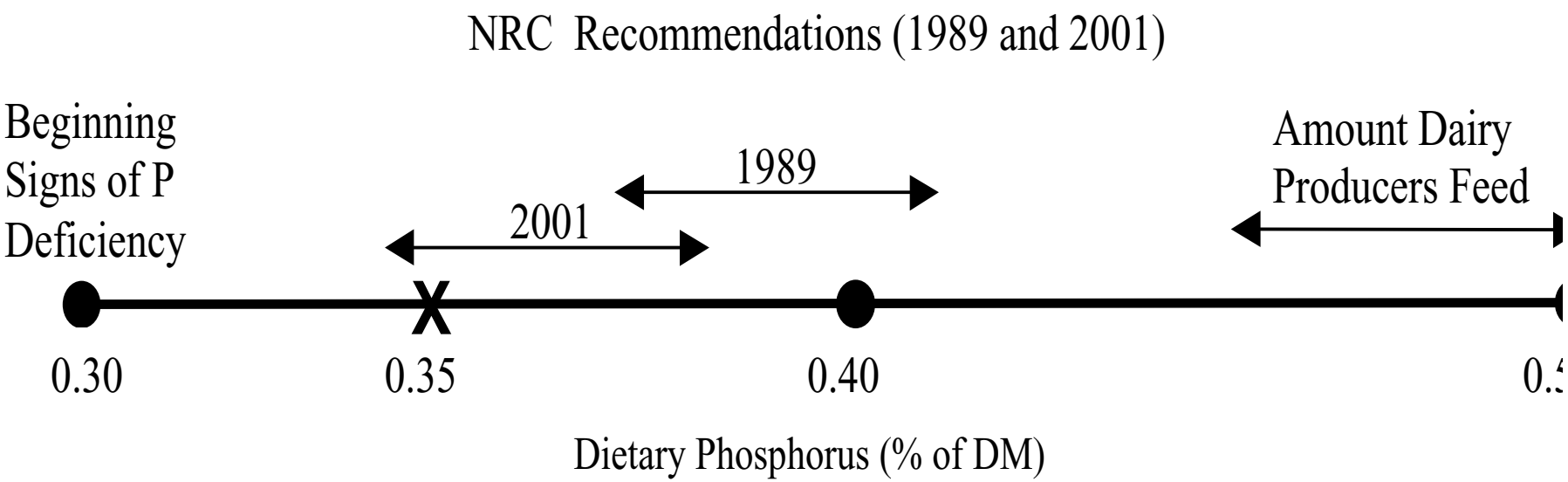
1. Reduce size of animal operation that will need permits from DNR as a point source of pollution.

Currently	Likely Proposed
1,000 Animal Units (700 dairy cows)	500 Animal Units (350 dairy cows)

2. Require phosphorus-based nutrient management planning in impaired watersheds.






NRC Recommendations (1989 and 2001)
Beginning Signs of P Deficiency
1989
2001
Amount Dairy Producers Feed
0.30
0.35
0.40
Dietary Phosphorus (% of DM)

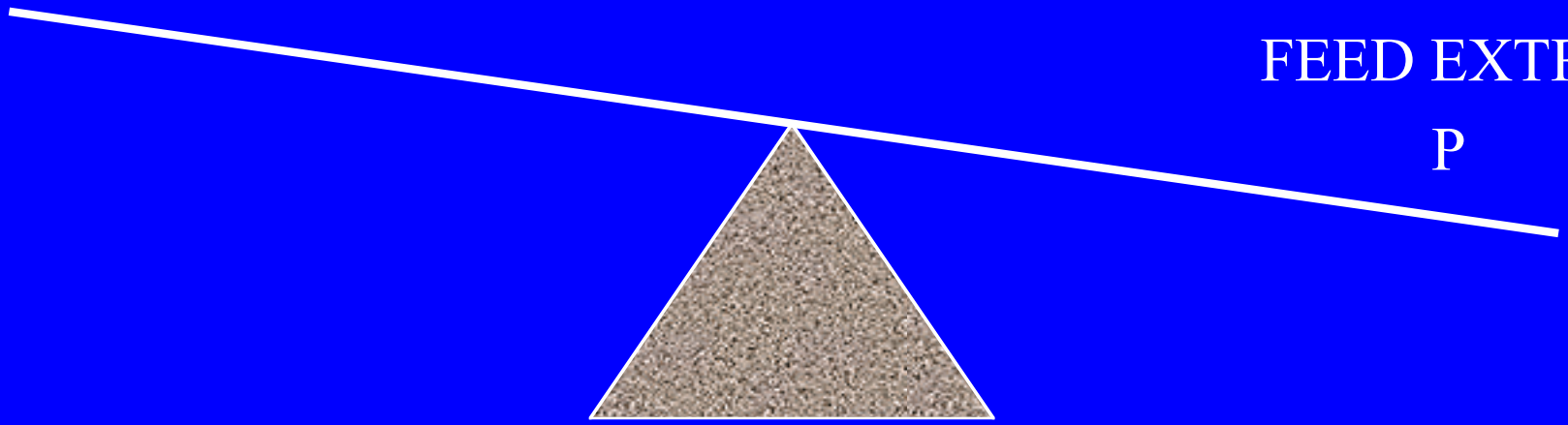
SHIFTING RISK

Yesterday

Cost of P Supplement

Environmental Cost

SAFER TO FEED EXTRA P



SHIFTING RISK

Tomorrow

Safer to
Feed Extra P

ENVIRONMENTAL COST

Cost of P Supplement